



RDECOM



Malcolm Baldrige
**National
Quality
Award**
2007 Award
Recipient

ARDEC Igniters for Gun Systems



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Eugene Rozumov, Carlton P. Adam, Thelma G. Manning, Joseph M. Laquidara, Kimberly Chung, Dave Thompson, Jeff Wyckoff, Viral Panchal
Armament Research Development Engineering Center

INSENSITIVE MUNITIONS & ENERGETIC MATERIALS TECHNOLOGY
SYMPOSIUM MAY 14-17, 2012

❖ Problems:

- Benite doesn't perform as well as BKNO₃ in 120MM tank rounds
- Benite gives inconsistent performance results.
- Future rounds need smaller igniter tubes.

❖ Solution:

- ARDEC has developed igniter formulations
 - **Excellent and consistent performance**
 - **Less sensitive than Benite**
 - **Is more energetic than Benite.**
 - **EXTRUDABLE**
 - **Smaller Ignition Delays**





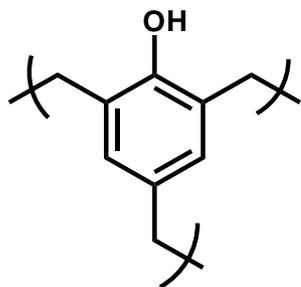
BKNO₃

- ❖ Made of:
 - 70% Potassium Nitrate
 - 30% Boron
- ❖ Easily ignited at low **P**.
- ❖ High Gas Content
- ❖ Burn Rate insensitive to **P**.
- ❖ Hygroscopic (less than Black Powder)

Benite

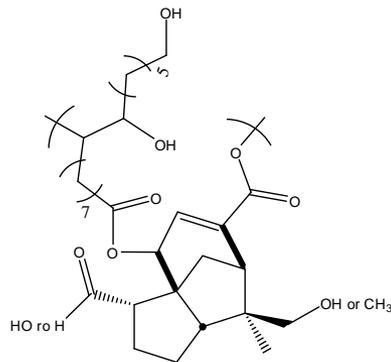
- ❖ Made of:
 - 40% Nitrocellulose
 - 6.3% Sulfur
 - 44.3% Potassium Nitrate
 - 9.3% Charcoal
 - 0.5% Ethyl Centralite
- ❖ Performance as an igniter is adequate for tank applications.

❖ One study examined the following using Closed Bomb:



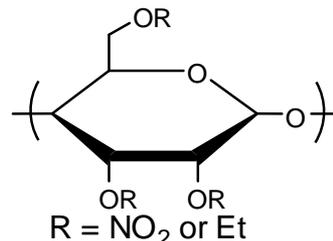
phenol formaldehyde resin

- Acid catalyzed polymerization of phenol and formaldehyde
- Common Name: Bakelite

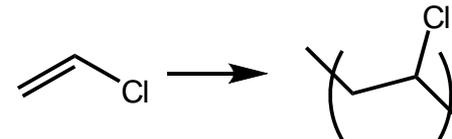


shellac

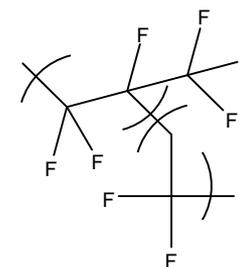
- Natural Product



NC and EC



PVC



Fluorel

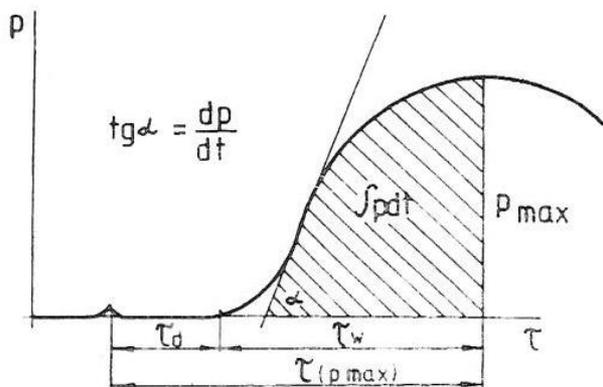


Table 5. Burning Characteristics of the Boron-based Igniters

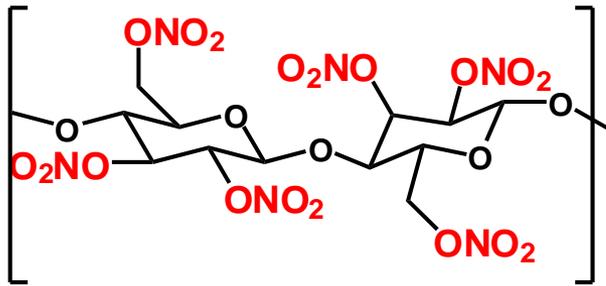
binder	PR	shellac	fluorel	EC	NC	PVC
parameter						
p_{max} [bar]	69.47	62.86	50.54	36.93	51.74	38.75
τ_d [ms]	12	12	20	13	34	15
$\tau(p_{max})$ [ms]	18	27	38	23	68	28
dp/dt [bar · s ⁻¹]	5053	4180	3965	3950	2824	4388

Barisin, , D.; Batinic-Haberle, I. *Propellants, Explosives Pyrotechnics* 1994, 19, 127.

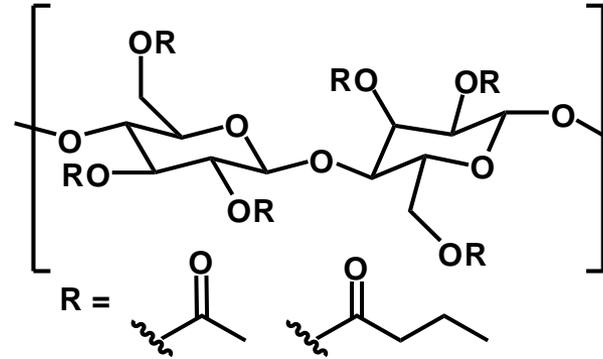
Distribution authorized for Public Release April 2012.



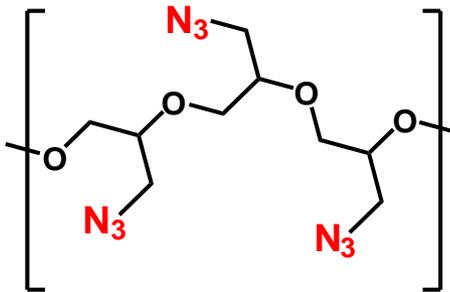
Properties of Binders Considered



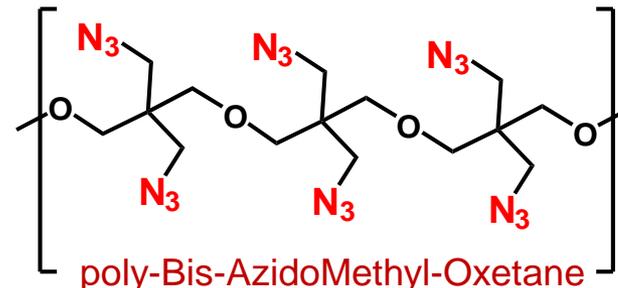
Nitrocellulose
 $\rho = 1.66 \text{ g/cc}$
 $\Delta H_f = -690 \text{ kJ/mol}$
 $T_v = 3331 \text{ K}$
 O.B. = -31%



Cellulose Acetate/Butyrate
 $\rho = 1.22 \text{ g/cc}$
 $\Delta H_f = -1630 \text{ kJ/mol}$
 $T_v = 1052 \text{ K}$
 O.B. = -160%



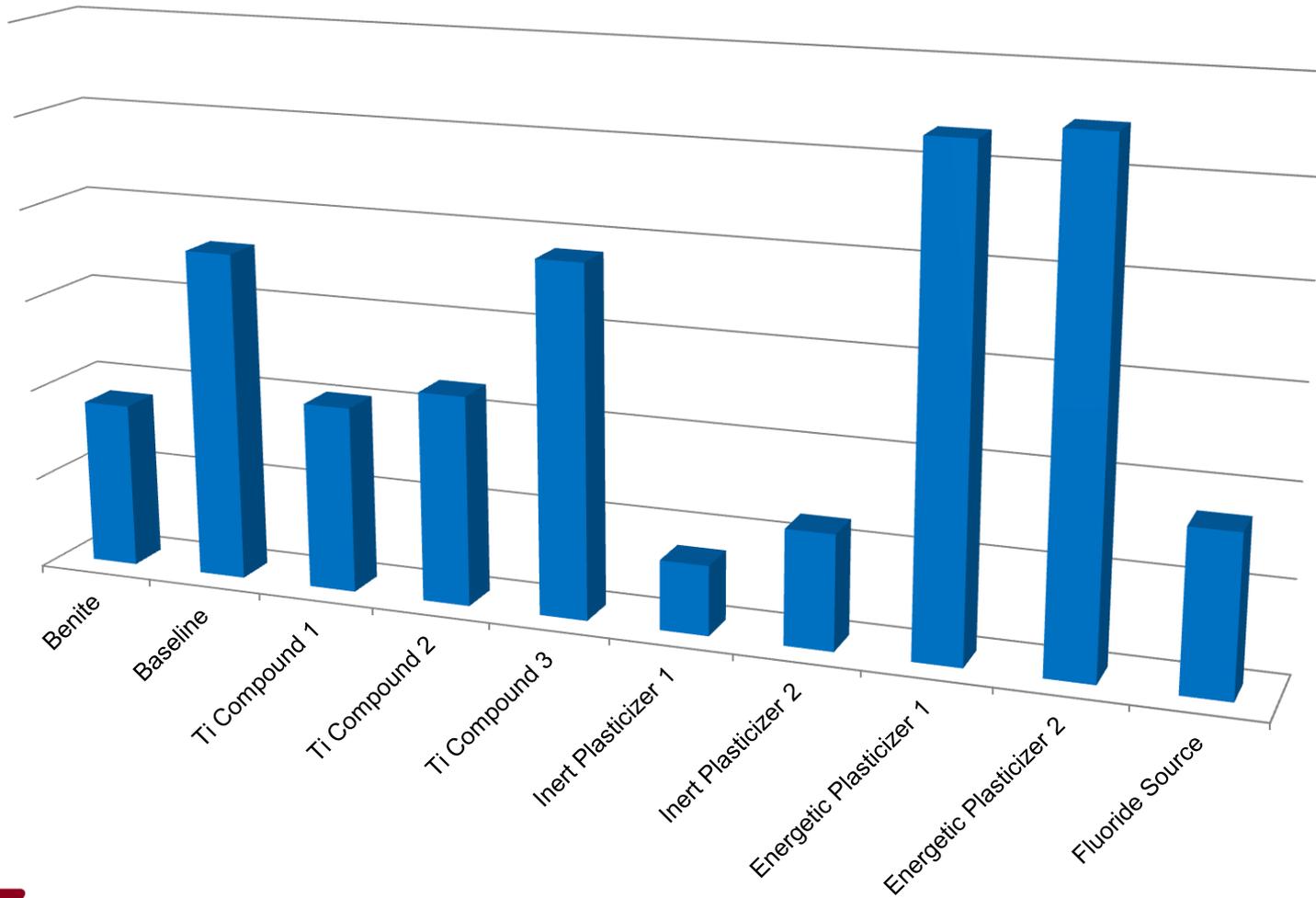
Glycidyl Azide Polymer (GAP)
 $\rho = 1.29 \text{ g/cc}$
 $\Delta H_f = 176 \text{ kJ/mol}$
 $T_v = 2288 \text{ K}$
 O.B. = -121%



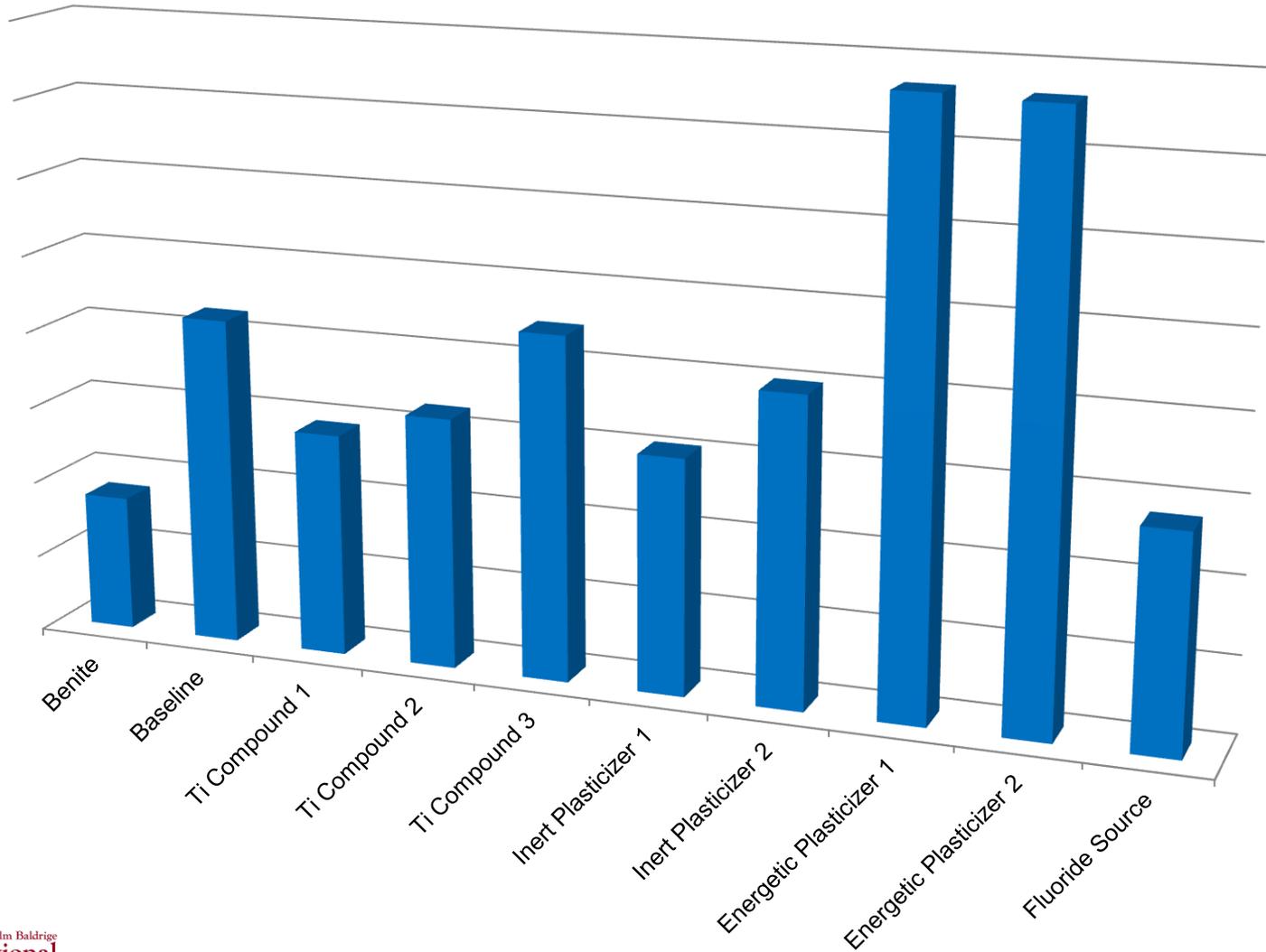
poly-Bis-AzidoMethyl-Oxetane
 $\rho = 1.30 \text{ g/cc}$
 $\Delta H_f = 373 \text{ kJ/mol}$
 $T_v = 2246 \text{ K}$
 O.B. = -124%

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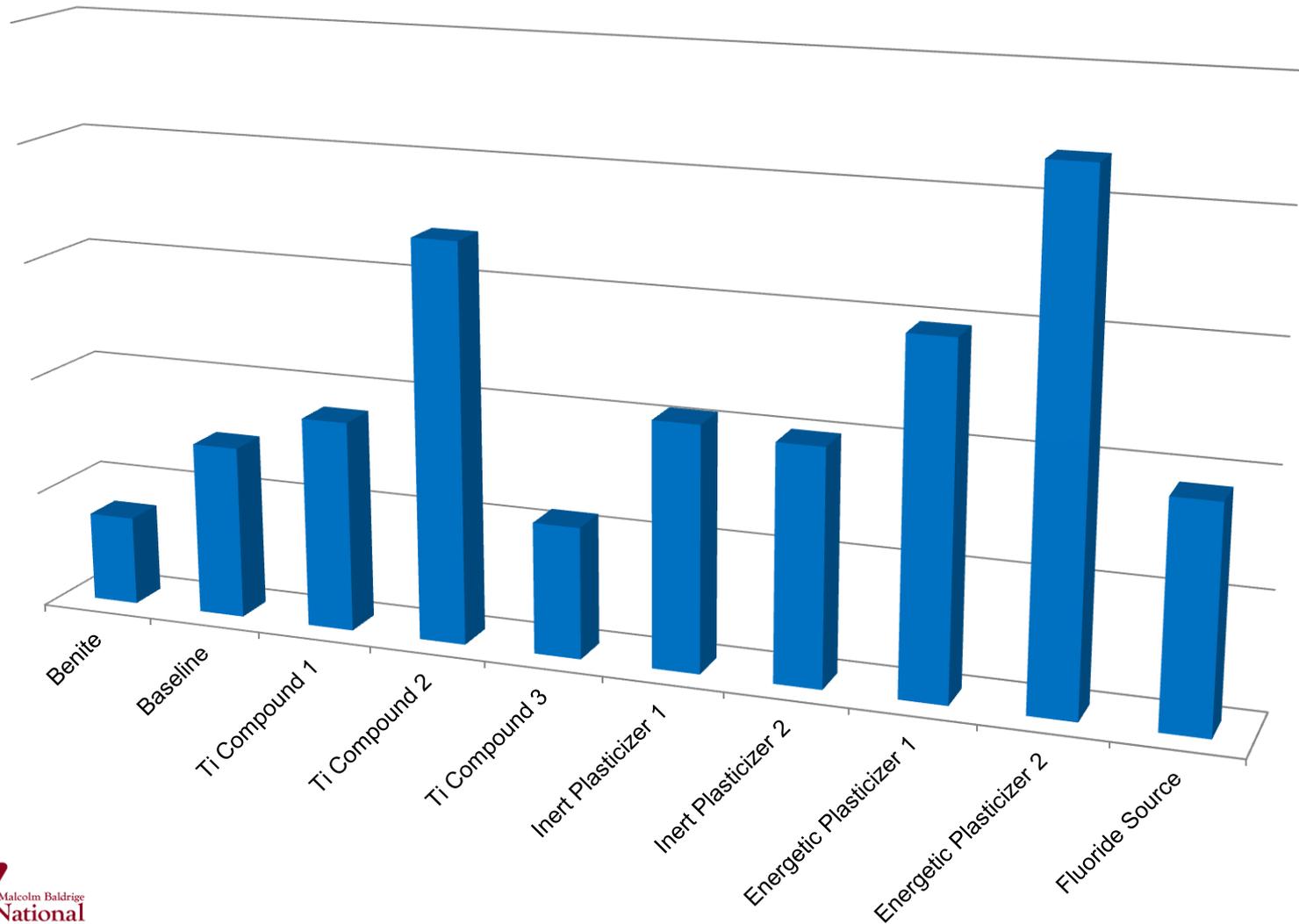
Calculated Flame Temperature



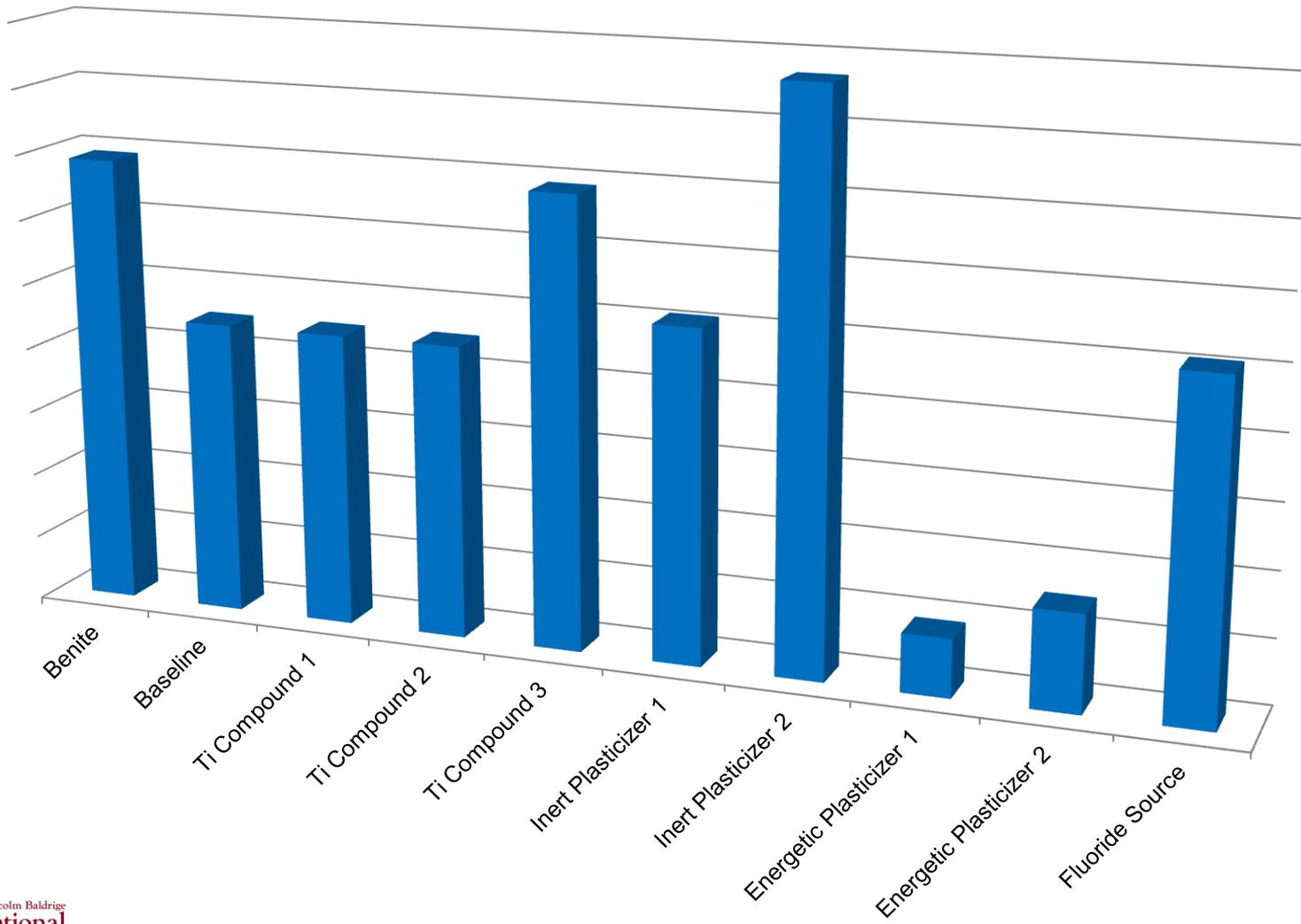
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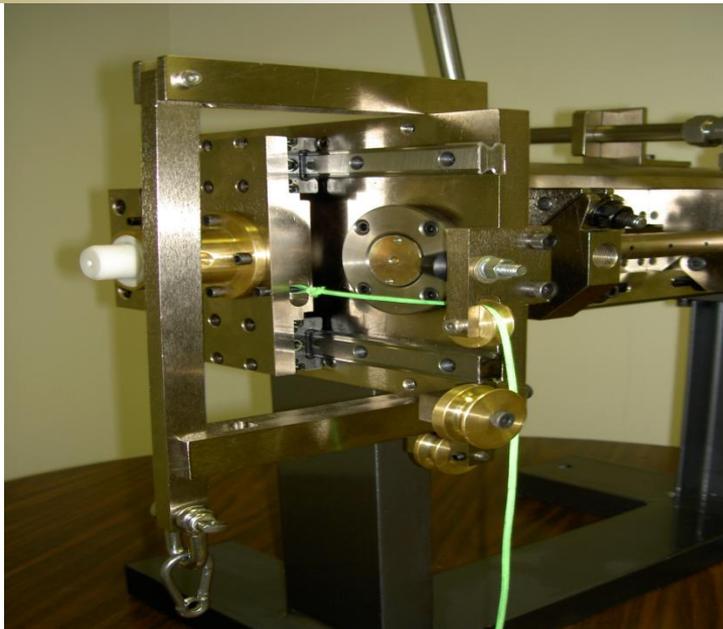
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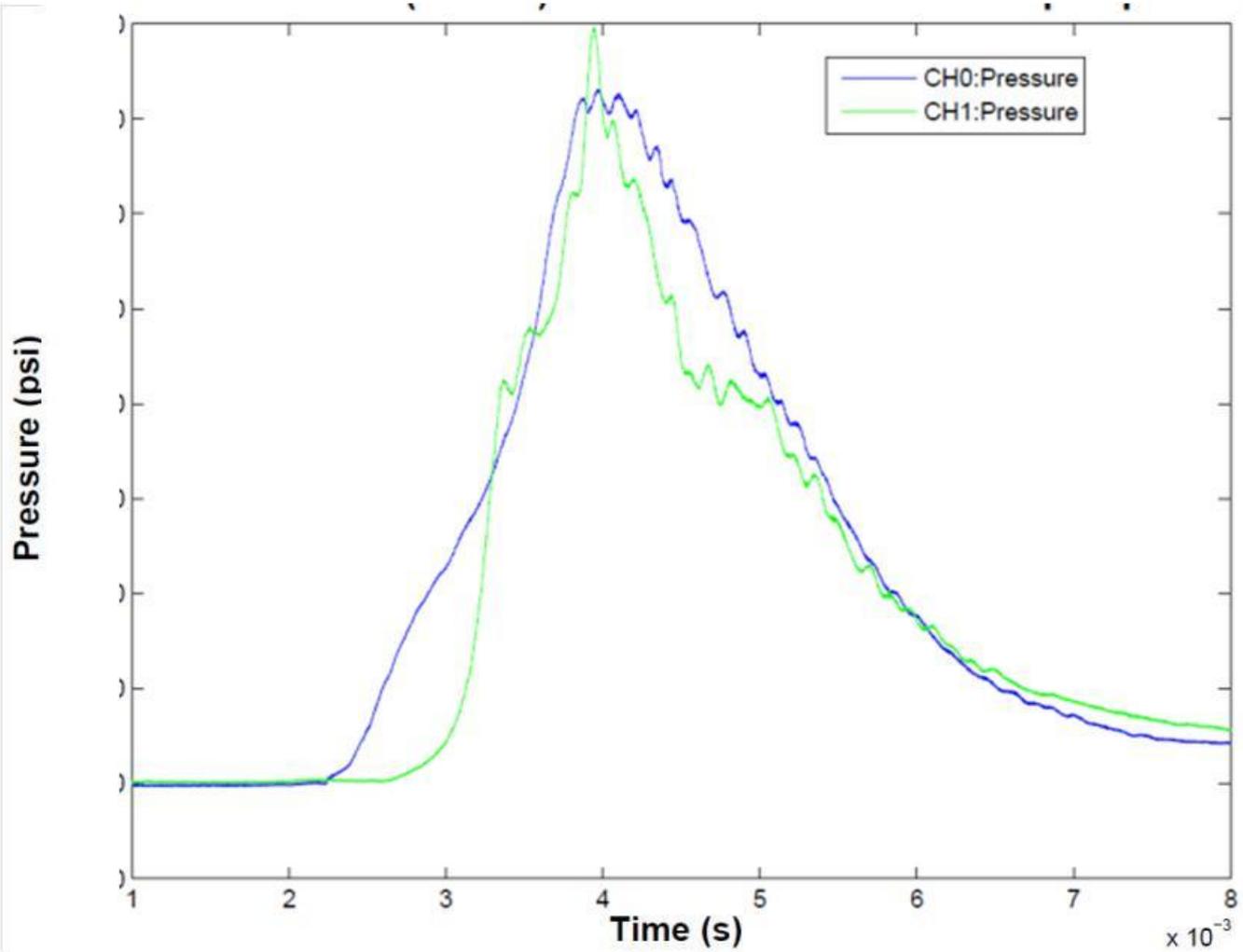


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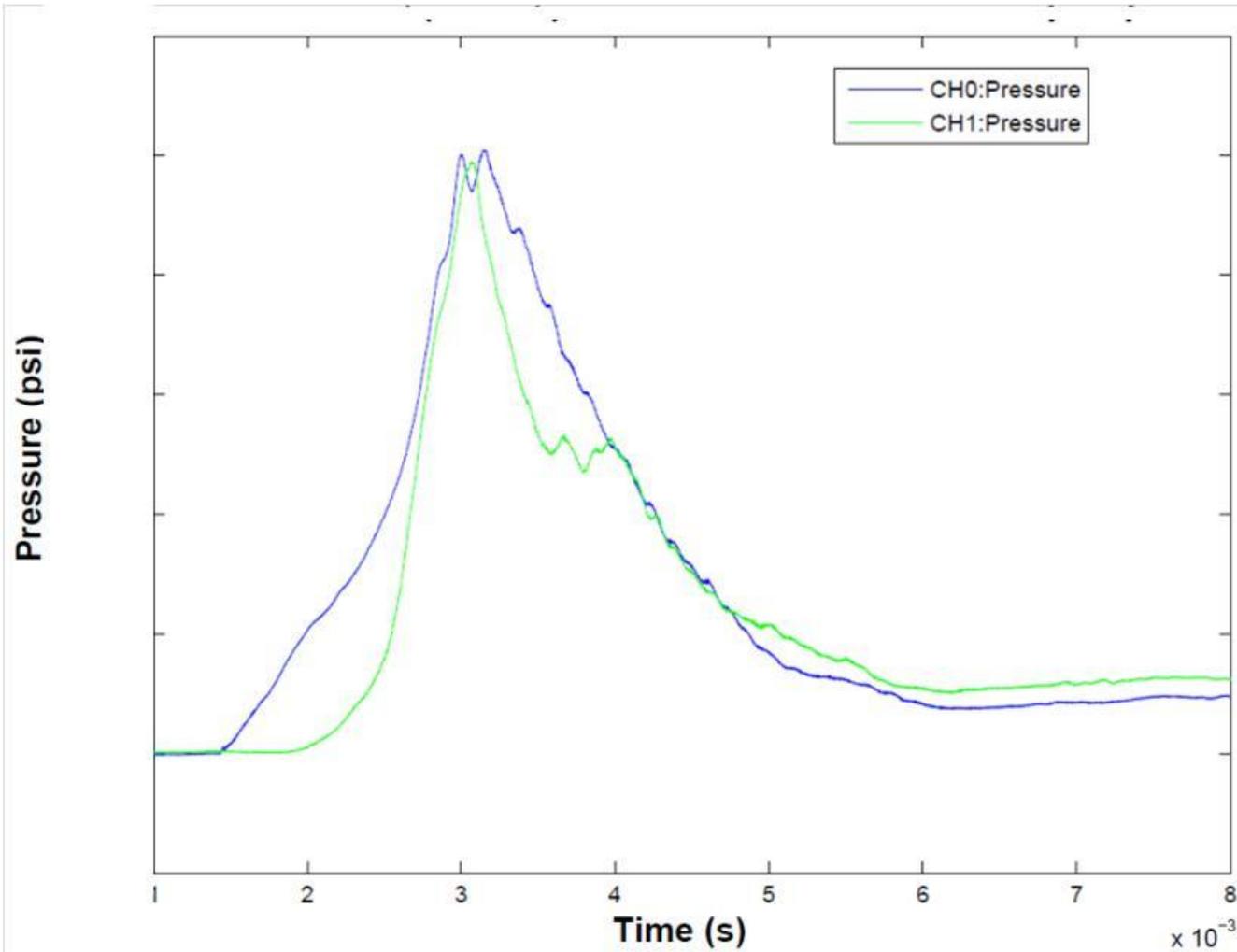


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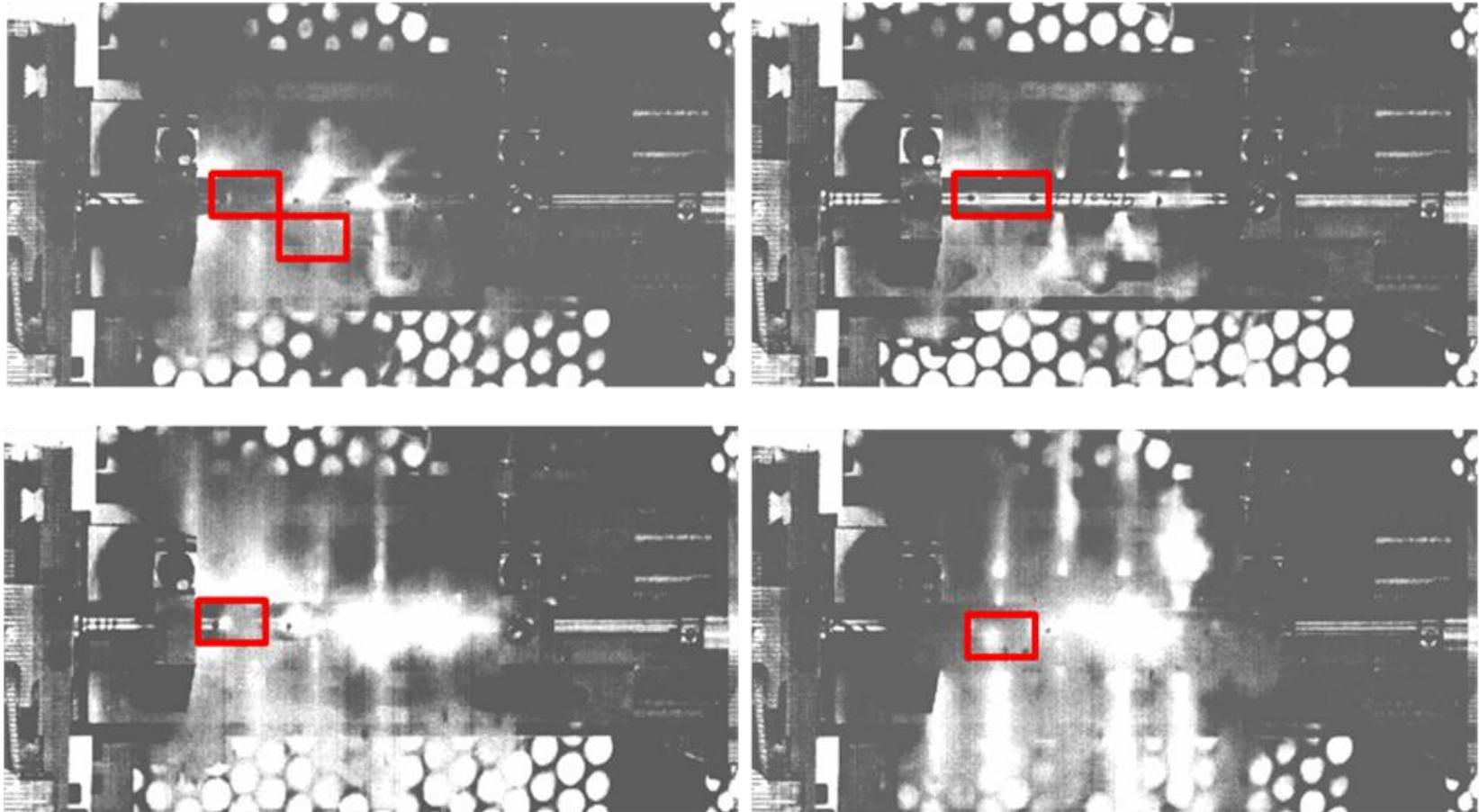


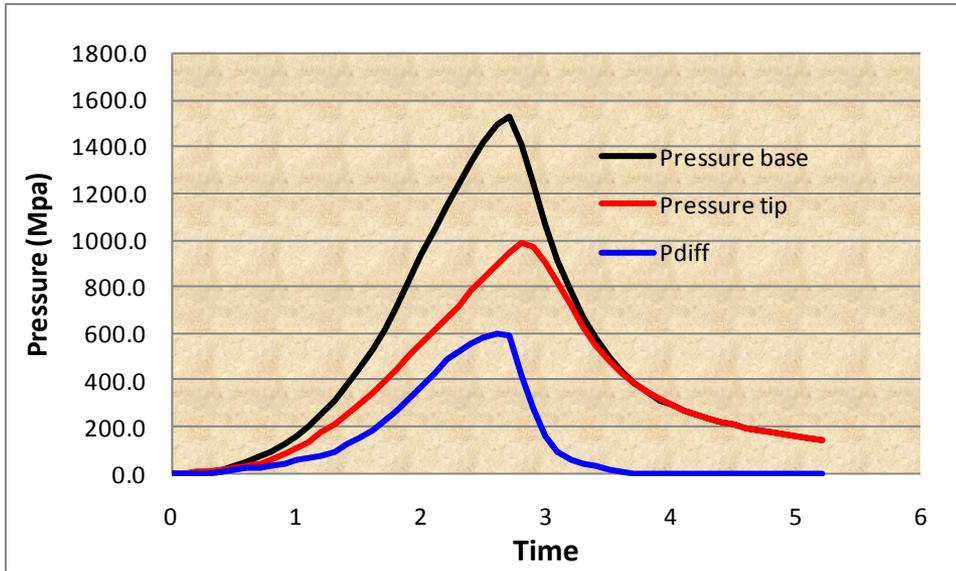
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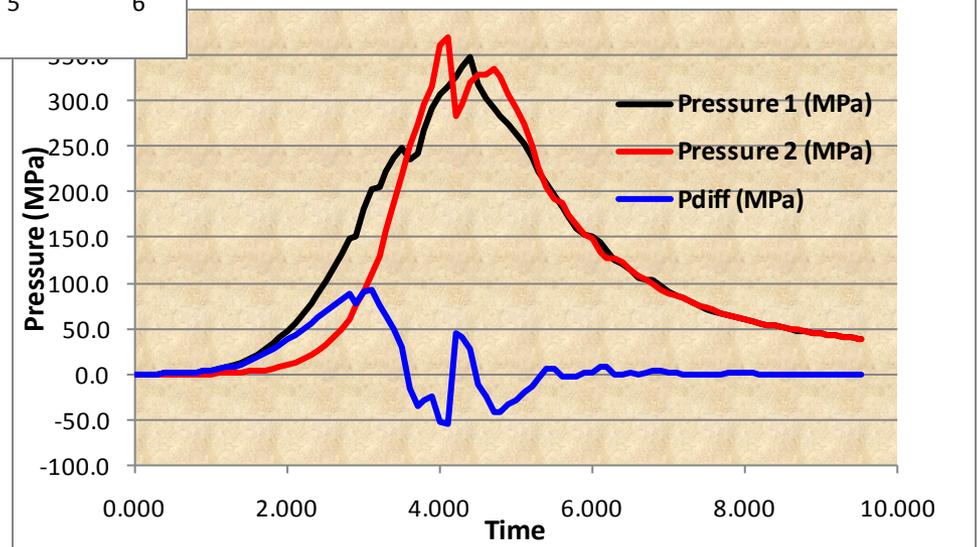
Factory Assembled Benite Primer



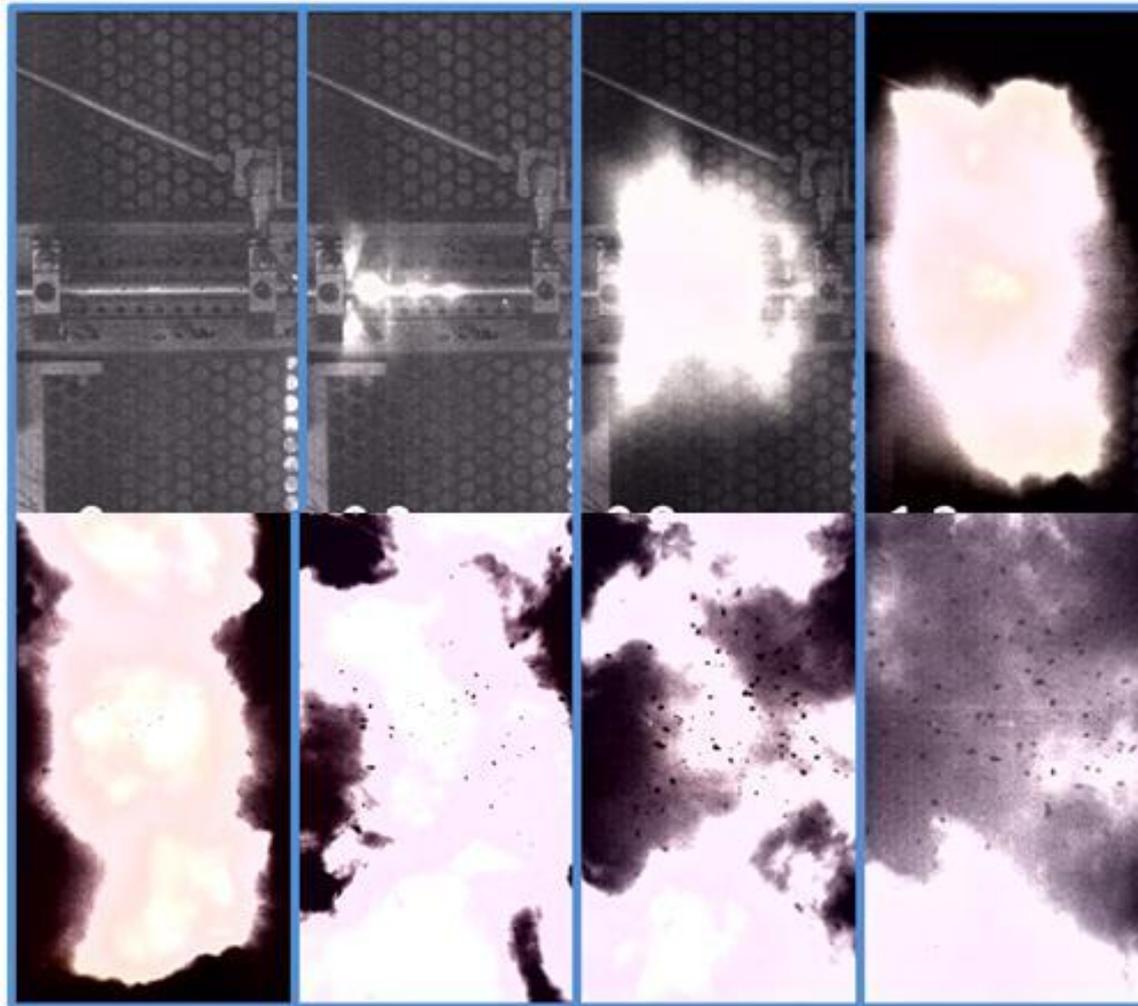


- ❖ Instantaneous Ignition along the igniter tube.
- ❖ No Pressure Differentials.

- ❖ Staged Ignition from the middle of the igniter tube.
- ❖ -50 MPa Pressure Differentials.



Representative BKNO_3 -NC Igniter



- ❖ **ARDEC developed igniters:**
 - **Excellent and consistent performance**
 - **Less sensitive than Benite**
 - **Is more energetic than Benite.**
 - **EXTRUDABLE**
 - **Smaller Ignition Delay**
 - **More Hot Particles**
 - **More Flame**